Energy Loss Minimization with Optimal Allocation of DG in Radial Distribution Network

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***Abstract* - In this dissertation work we are mainly focussed on Load flow analysis of Radial distribution system. In this dissertation work, we are going to simulate an IEEE-33 Bus system by using the BFS Algorithm in MATLAB, for solving the load flow problems. Firstly, we are going to make the radial distribution system of proposed test system in MATLAB in which we have to estimate the voltage magnitude profile and active power and reactive power losses at individual bus. In this work we use the BFS algorithm is utilized for calculating the load flow investigation in proposed system. By using the concept of distributed generation, we are going to estimate the optimum allocation of DG which is best suited for this system, where we have to manage the voltage value and power losses of the whole system In this work we are estimating VOLTAGE STABILITY INDEX at each bus, To estimate the accurate place of Distributed generation. After that size of DG is our main concern. When Distributed generation is inserted in the system, find the voltage profile and power of the system, and find the losses of the system.After DG placement, comparative analysis is being made for voltage profile and loss minimization. And VOLTAGE STABILITY INDEX is being calculated with and without DG. On comparing the results we see that the voltage profile and power losses are very much reduced by using distributed generation concept.**

INTRODUCTION

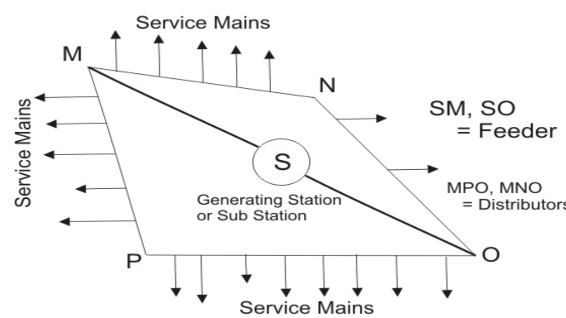
Introduction to Power system

An electric power system is utilized to provide electricity and utilize that power which is a network of electrical components. An example of this is the network that provides electricity to a particular area's homes and industry, this type of system is known as the grid system and classified as generators that generate and transfer electric power. A system which transmits electric power from the generating centres to the load centres known as transmitting system whereas system which distribute power to houses and industries known distribution system.

There are some criteria or characteristics for effective operation of a power system and they are stated as:

To satisfy the demands of various load buses and many losses requires a satisfactory amount of power generation. The magnitude of the bus voltage should be maintained at a very close value to the rated voltage value.

At any instant of time, the generators and



LOAD FLOW STUDY

Introduction

Load flow study is considered as one of the considerable parts of the power systems arranging & also the process. And also it give the sine wave based stable state or situation for the whole system including the voltages, the genuine and also the mechanical power formed and ingested and also the line delicate. And as the load is the static sum and also the power circulated via transmission lines, the idealist likes to know as the Power Flow concentrate as opposed to load flow study. Standard Procedure For the formulation of load flow problem in power system

PROPOSED WORK

This chapter deals with the problem formulation for optimal sizing and location of distributed generation in the radial distribution network. Problem Formulation: This section deals with development of mathematical model for objective function and different constraints for radial distribution system in the presence of Distributed generation.

Objective Function:

The objective of the optimal size and location of DG problem to minimize the total power loss and voltage profile can be expressed as

Minimize $PL = \sum_{i=1}^{n}\sum_{j=1}^{n} [\alpha ij(PiPj + QiQj) + \beta ij(QiPj - PiQj)]$ (5.1)

Where

$$\alpha ij = \frac{rij}{vivj}\cos(\delta i - \delta j)$$

$$\beta ij = \frac{rij}{vivj}\cos(\delta i - \delta j)$$

Zij = rij + jxij

Where

Zij is the impedance of the line between bus i and bus j;

rij is the resistance of the line between bus i and bus j;

xij is the reactance of the line between bus i and bus j;

Vi is the voltage magnitude at bus i

Vj is the voltage magnitude at bus j

Backward- Forward Sweep Algorithm Method

Power engineers facing many problems due to the increase in the power demand, voltage instability and transmission line overloading. Reactive power unbalancing, voltage collapse, unexpected lines and generator outages are the major cause of voltage instability. The problems of improving voltage profile and decreasing power losses in any system can be solved by optimal ways. There are the problems of single and three phases.

Now, FACTS devices and load flow studies are the solution for the improvement of the voltage profile and stability of present power system. For minimize transmission line losses and improve voltage stability, a backward forward sweep method based on the approach for load flow analysis of an IEEE 33 bus test system is used.

To understand the nature of the installed network load low studies are performed. It is used to determine the static performance of the system. Power systems are analysed in steady-state operation. Some special features of distribution networks are as follow in category

- Radial or weakly meshed networks
- High R/X ratios
- Multi-phase, unbalanced operation
- Unbalanced distributed load
- Distributed generation

In this paper, a new method for solving the power flow problem for distribution feeders without using conventional load flow methods (Gauss Seidel, Newton Raphson, and Fast Decoupled) is presented. This method uses simple algebraic equations to find out iteratively of outgoing powers and voltage magnitudes of various nodes and mismatches at the last nodes of main feeder and so on and depending upon mismatches the substation injection is corrected judiciously and this process is repeated until convergence. This makes the algorithm very robust and numerically efficient for convergence for wide variation of distribution network.

Simulation and Results

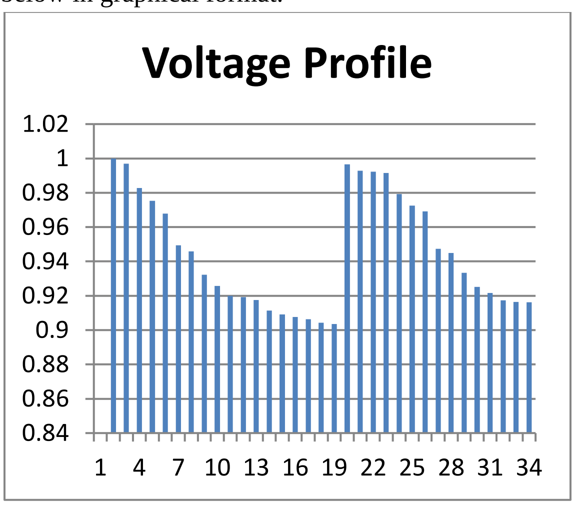
In order to test the effectiveness of the proposed controller, the algorithm was tested on standard IEEE radial distribution networks. These are the IEEE 33-bus radial network. These networks were chosen because they have been used extensively in literature for radial distribution network analysis. The proposed controller was first tested on the IEEE 33 bus network. Load and line data for this network are given in tables. The total installed peak loads on the system are 3715 kW and 2290 kVAr. Base voltage is 12.66kv. The topology of the network is illustrated below.

In this chapter we have done the load flow analysis of IEEE 33 bus system using forward backward sweep algorithm and find out the voltage profile and power losses of the particular radial distribution system. We also find the voltage stability index of IEEE 33 bus system. further we have to use the concept of distributed generation and find the optimal location of DG in IEEE 33 bus system system, where we got the minimum losses and size of DG is also our main concern. Here we use three type of DG which has different power factor. For different power factor, size of DG is also different and then find the comparative analysis of all DG in this work.

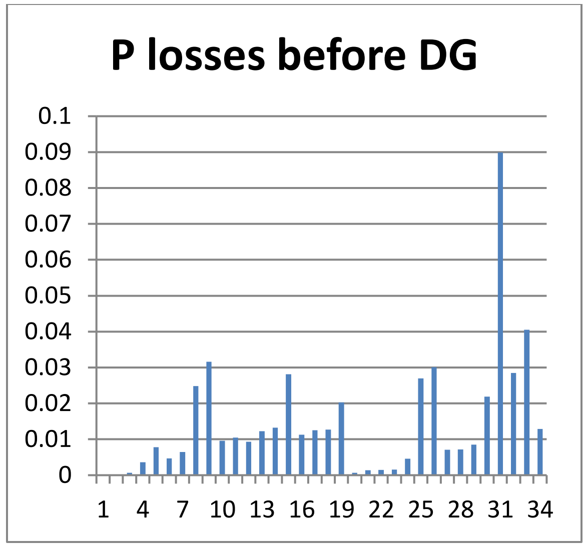
Algorithm for Load Flow analysis of IEEE 33 Bus Ststem:

Step-1 Load bus data and line data of IEEE -33 bus for base case
Step-2 Using forward backward sweep method make the load flow analysis
Step-3 find out the voltage profile and power losses in load flow flow analysis
Step-4 Find out the voltage stability index for IEEE 33 bus system
Step-5 Find out the optimal allocation of DG where we have to place DG which gives minimum power losses.
Step-6 For three different types of DG, place DG one by one and get the results
Step-7 Find the voltage profile and power losses at each bus after DG placement
Step-8 Comparing the voltage profile and power losses

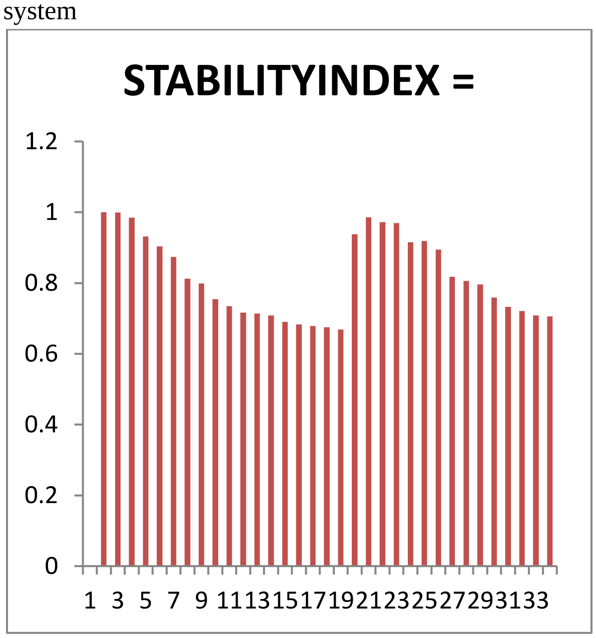
Step-2 Using forward backward sweep method make the load flow analysis
In MATLAB, we are going to solve the load flow problem with help of programming and will find their data's and results and then comparing the results obtained from both the approaches.
Step-3 find out the voltage profile and power losses in load flow flow analysis:-Following are the Data's obtained in MATLAB after programming as: After Load flow analysis using backward Forward sweep algorithm the voltage profile at all the buses is shown below in graphical format.



Voltage profile Of IEEE 33 Bus system
The power losses obtained after backward forward algorithm of IEEE 33 bus system are given in graphical format as shown in 5.3. Total real power demand is 3715 kW and reactive power demand is 2295 kW. Total real power losses after using this backward forward algorithm is 502 kW.



Real power Losses before DG placement
Find out the voltage stability index for IEEE 33 bus system

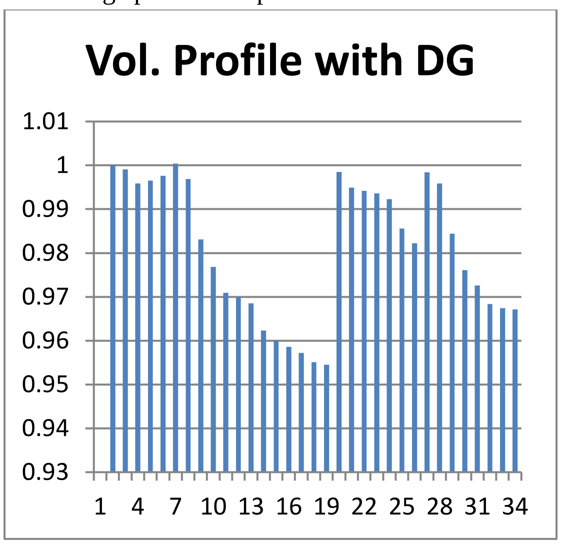


Stability Index of IEEE 33 bus system without DG

After load flow analysis by forward Backward algorithm, For an IEEE 33 bus system the voltage profile and real power losses is shown above after that we have calculated one stability indices that is VOLTAGE STABILITY INDICES is calculated for this system and result are shown in above figure. The minimum voltage received at bus 18 is 0.9036 and minimum stability index at bus 18 is 0.6686. Total real power losses after using this backward forward algorithm is 502 kW .

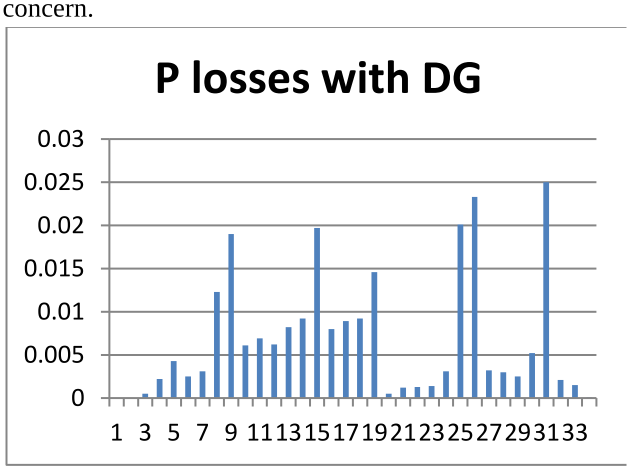
Step-5 Find out the optimal allocation of DG:- where we have to place DG which gives minimum power losses. (for power factor 0.85) For optimum allocation of DG we have to use the objective function which we have discussed in previous chapter. By programming we get the optimal allocation which is bus no 6, when we place the DG at 6th bus losses are reduced to be minimum. Sizing of DG is our main concern, so by objective function we get size of DG by programming. The active power for DG is 3051.5 kW and reactive power for DG is 1891.1 kW

After placing the DG in the IEEE bus system at 6th bus. The voltage profile and power losses will be



Voltage Profile of IEEE 33 Bus system after placing DG

The Real power losses after placing DG in the IEEE 33 Bus system is shown in figure. Total real power losses after DG placement is 234.4 kW which is 53.39 percent reduced to real power losses which is our main concern.



Real Power losses with DG placement in IEEE 33 bus system

The next step is to find the Voltage stability index of an IEEE 33 bus system with DG placement is shown in fig. The minimum voltage after DG placement is 0.8321 at bus 18.

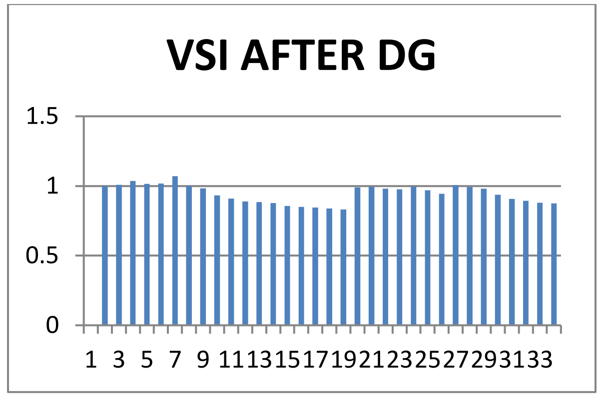
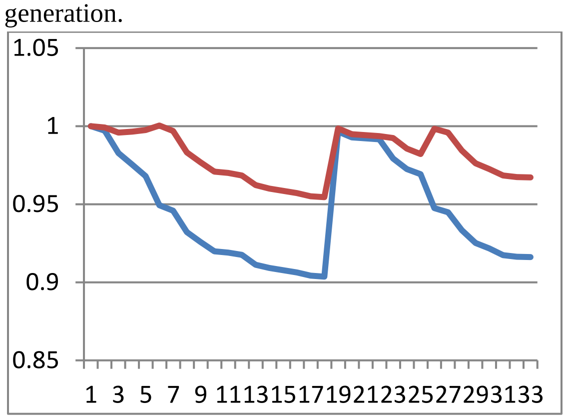


Fig 5.6 Voltage Stability Index With DG of IEEE 33 bus system

Comparative analysis of With DG and Without DG: On comparing the voltage profile of an IEEE 33 bus system with and without DG, comparison is made in tabular format is shown is table. The minimum voltage when working as without DG is 9036 and with DG is 0.9545 at bus 18. This means that the voltage profile is very much improved using the distributed generation.



Voltage profile comparison of IEEE 33 bus system with and with out DG

Now the next step is to see what happens in the power losses using DG. On seeing the comparative analysis of real power losses power with DG is 234.4 kW and with out DG is 503 kW. This means that real power losses is 53.39 percent reduced.

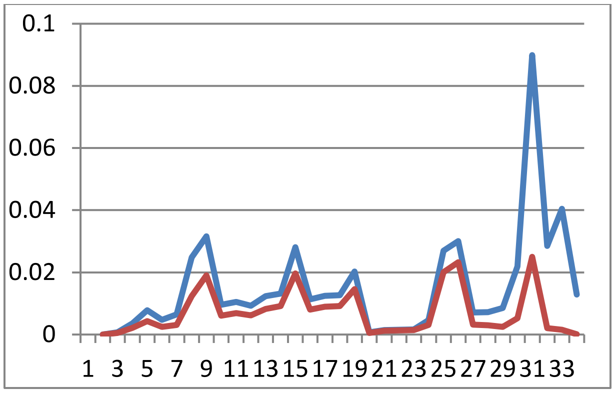


Fig 5.8 Comparision of Real power losses with and without DG

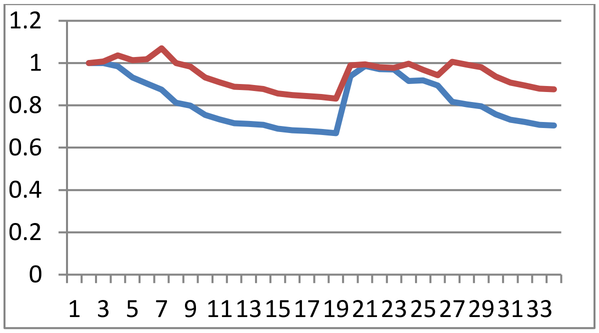


Fig 5.9 Comparision of Voltage Stability Index with and without DG

The minimum voltage stability index of an IEEE 33 bus system at bus 18 is 0.6686 when we are not using DG. After DG placement the minimum voltage stability index increases to 0.8321. This means that voltage stability index is very much improved. This indicates that the system is near to be in stable condition.

CONCLUSION

This dissertation work illustrated the optimal Distributed Generation placement-based approach for the analysis of load flow problems in radial distribution system with the help of MATLAB based software. Size and location of DG are fundamental factors in the application of DG for loss minimization. An analytical expression based method is proposed for finding the optimal size of DG and location is found where loss is minimum. It has been shown that voltage profile is significantly improved by placing DG in Distribution system and the losses have been reduced by 53.39%. In practice, the choice of the best site may not be always possible due to many constraints. However, the analysis here suggests that the losses arising from different placements vary greatly and hence this factor must be taken into consideration A Distributed Generation which is connected over the most critical bus on a IEEE 33 Bus test system for improving the voltage magnitude profile and reducing the total losses in the system. The simulation of the IEEE 33 bus system over critical bus is done with or without using the DG and the obtained results are compared thereafter.

The algorithm is applied in this dissertation i.e. Backward-Forward Sweep Algorithm Method in MATLAB and a comparison is plotted between the results obtained from the both the approaches. Finally, after the comparison of results from both the approaches, we concluded that the simulation of IEEE 33 bus system by using the approach of Backward-Forward Sweep Algorithm Method in MATLAB gives far better results in comparison to the approach based on the Distributed Generation for the improvement of Voltage magnitude profile and reduction of total power losses in the system.

REFERENCE

[1] D. Bhujel; B. Adhikary; A. K. Mishra A Load Flow Algorithm for Radial Distribution System with Distributed Generation 2012 IEEE Third International Conference on Sustainable Energy Technologies (ICSET) Year: 2012 Pages: 375 - 380, DOI: 10.1109/ICSET.2012.6357429.

[2] Saeed Jahdi; Alidad Etemadian Loi Lei Lai DG modeling and compensation methods in distribution load flow analysis and voltage profile recovery Published in: 11th International Conference on Electrical Power Quality and Utilisation (EPQU), 2011 12 January 2012 DOI: 10.1109/EPQU.2011. 6128962.

[3] A. Elmitwally A new algorithm for allocating multiple distributed generation units based on load centroid concept,. [a] 2013 Production and hosting by Elsevier B.V. on behalf of Faculty of Engineering, Alexandria University.

[4] P. Vijay Babua & S.P. Singhb* Optimal Placement of DG in Distribution network for power loss minimization using NLP & PLS Technique, 5th International Conference on advances in Energy Research, ICAER 2015, 15-17 December 2015, Mumbai, India

[5] Pradeepa. Ha*, Dr. T. Ananthapadmanabhaa, Sandhya Rani D Na, Bandhavya Ca Optimal

Allocation of Combined DG and Capacitor Units for Voltage Stability Enhancement Procedia Technology 21 (2015) 216 – 223 Available online at www.sciencedirect.com Peer-review under responsibility of Amrita School of Engineering, Amrita Vishwa Vidyapeetham University doi: 10.1016/j.protcy.2015.10.091 SMART GRID Technologies, August 6-8, 2015

[6] Ram Singh1, Gursewak Singh Brar2 and Navdeep Kaur3 Optimal Placement of DG in Radial distribution Network for Minimization of Losses *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 1, Issue 2, August 2012*

[7] B. Ravi Teja1, V.V.S.N. Murty2, Ashwani Kumar an Efficient and Simple Load Flow Approach for Radial and Meshed Distribution Networks International Journal of Grid and Distributed Computing Vol. 9, No. 2 (2016), pp.85-102

[8] A. Appa Rao1, M. Win Babu2, K.S. Linga Murthy Forward Sweeping Method for Solving Radial Distribution Networks International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 2, Issue 9, September 2013

[9] G KALIDAS BABU1 & RAJESH KUMAR SAMALA2 LOAD FLOW ANALYSIS OF 9 BUS RADIAL SYSTEM USING BFSLF ALGORITHM International Journal of Electronics and Communication Engineering (IJECE) ISSN(P):2278-9901; ISSN(E): 2278-991X; Vol. 4, Issue 6, Oct - Nov 2015, 17-22 © IASET

[10] RM Saloman Danaraj*, Shankarappa F Kodad** and Tulsi Ram Das***An algorithm for radial distribution power flow in Complex mode including voltage controlled buses Indian Journal of Science and Technology http://www.indjst.org Vol.1 No.2 (Dec. 2007)

[11] Neeraj KANWAR1, Nikhil GUPTA1, K. R. NIAZI1, Anil SWARNKAR1 Optimal distributed generation allocation in radial distribution systems considering customer-wise dedicated feeders and load patterns J. Mod. Power Syst. Clean Energy (2015) 3(4):475–484DOI 10.1007/s40565-015-0169-0

[12] Mukul Dixit Prasanta Kundu Hitesh R. Jariwala Optimal Placement and Sizing of DG in Distribution System using Artificial Bee Colony Algorithm 978-1-5090-0128-6/16/$31.00 ©2016 IEEE